PATENT SPECIFICATION (11) 1 450 251

1 450 251

(21) Application No. 883/74 (22) Filed 8 Jan. 1974 (19)

(44) Complete Specification published 22 Sept. 1976

(51) INT. CL.[2] B26F 3/14

(52) Index at acceptance
B4B 70E

(72) Inventors DAVID EARL MOMINEE
and GILBERT WILLIAM VANCE

(54) CREATING HOLES IN MEMBERS

(71) We, REED IRRIGATION SYSTEMS, formerly known as Reed Irrigation International, a Company incorporated in the State of California, United States of America, of 4466 North Baldwin Avenue, El Monte, California 31731, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for creating holes in a member, particularly but not exclusively in a tube.

The invention has particular application in the manufacture of irrigation of water distribution tubing, of the type having a series of holes along its length.

The simplest form of such a tube consists of an elongated tubular member, normally a member of circular cross-sectional configuration, having comparatively fine holes spaced along its length. It has been discovered that tubes having an internal wall dividing them into two internal sections and having periodically spaced holes in this internal wall are more desirable than simple tubes having undivided interiors for water distribution purposes because with such internally divided tubes it is possible to obtain a pressure step-down effect tending to restrict the amounts of water emitted from the external holes employed.

With both of these types of tubular irrigation conduits a problem has been encountered in creating the holes used so that these holes are of a carefully controlled dimension so that the amounts of water emitted through them and/or passing through them will be regulated in order to achieve substantially uniform water distribution along the length of a tube and/or in order to achieve controlled water distribution along the length of a tube. In connection with this it will be realized that such controlled water distribution is necessary for efficient, economic irrigation without the waste of water.

This problem is considered to be particularly severe because of the fact that strength and material thickness considerations have made it desirable to utilize seamless tubes for water or similar distribution purposes. Such seamless tubes are comparatively hard to process utilizing conventional hole producing methods so that holes are created in them which are extremely uniform in character and/or are of a carefully controlled character, and which are of such a nature that their interiors do not contain internal fragments or projections which might interfere with a controlled or metered distribution of water.

According to one aspect of the present invention there is provided apparatus for making a hole in a member, the apparatus comprising: moving means for moving the member through a hole-making station; and directing means for directing a moving laser beam against a region of the member as that region passes through the hole-making station, the directing means being synchronised with the moving means in such a manner that, in use, the point of contact of the laser beam with the member moves through the hole-making station in the same direction that the said region moves through the hole-making station whereby the said point of contact remains within the said region throughout the movement of the said region through the hole-making station and the laser beam forms a hole in the member in the said region.

According to another aspect of the present invention there is provided a method of making a hole in a member comprising the steps of moving the member through a hole-making station; and directing a moving laser beam against a region of the member as that region passes through the hole-making station to form a hole in the member, the movement of the laser beam being synchronised with the

movement of the member in such a manner that the point of contact of the laser beam with the member moves through the hole-making station in the same direction as the said region moves through the hole-making station whereby the said point of contact remains within the said region throughout the movement of the said region through the hole-making station.

In order that the invention may be fully understood two embodiments thereof will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is an end elevational view of a presently preferred embodiment of apparatus according to an embodiment of the invention;

Figure 2 is an enlarged view of part of the apparatus shown in Figure 1;

Figure 3 is a partial cross-sectional view taken at line 3-3 of Figure 2;

Figure 4 is a diagrammatic view indicating the operation of certain of the parts shown in the preceding Figures;

Figure 5 is a partial cross-sectional view illustrating the angle of incidence of a laser beam;

Figure 6 is a partial cross-sectional view of a diagrammatic pipe illustrating the path taken by a laser beam taken along line 6-6 of Figure 4;

Figure 7 is a view corresponding to Figure 4 of a further embodiment of the invention;

Figure 8 is a view corresponding to Figure 6 taken along line 8-8 of Figure 7.

In Figure 1 of the drawings there is shown an apparatus 10 which includes a conventional base 12 supporting an upstanding housing 14. Within the interior of this housing 14, there is located known or conventional means 16 for generating a laser beam 18 of sufficient energy to heat a thermoplastic or other flexible material to create a hole or opening therein.

In the apparatus 10 such a beam 18 is reflected against a series of three mirrors 20 mounted within the housing 14 so that the beam 18 travels horizontally towards the center region of a wheel 22 serving as a continuous moving member as hereinafter indicated. This wheel 22 is mounted upon a shaft 24 supported by a bearing 26 located on an internal wall 30 within the housing 14. A conventional motor, such as a known variable speed motor 32 may be connected to the shaft 24 so as to rotate it. Other conventional mechanical means can be used to rotate the wheel 22.

Preferably the beam 18 travels towards the wheel 22 along the axis of this wheel 22 so as to pass through a known, conventional so-called trimmer 34 in such a manner as to engage a mirror 36 set at a 45° angle to the plane of the wheel 22. This trimmer 34 is preferably used in a conventional manner during the operation of the apparatus 10 so as to control the beam 18 used. It is considered well-established to control the size, energy and diffraction of a beam such as the beam 18 by a device of the type of the trimmer 34.

For convenience the mirror 36 is mounted on a small mounting plate 38 which is secured to the wheel 22. In the apparatus 10 this mounting plate 38 also holds a known condensing lens 40 located in the path of the beam 18 as it is reflected by the mirror 36 and another mirror 42 which reflects the beam 18 as it passes from the lens 40, towards a small opening 44 located in a peripheral flange 46 formed on the periphery of the wheel 22.

The flange 46 is of a depth and configuration corresponding to a part of the depth of a tube 50 to be perforated. This tube 50 preferably should be of a conventional flexible thermoplastic material such as a known plasticized vinyl polymer composition or other similar composition. In effect the groove 48 should be sufficiently deep so that the tube 50 may be held by tension wheels 52 within it without relative motion between the tube 50 and the flange 46 during the operation of the apparatus 10.

These tension wheels 52 are mounted upon arms 54 and 56 which are secured to small coacting gears 58. Both these arms 54 and 56 and the gears 58 are rotatably mounted upon shafts 60 so that a single biasing means such as the spring 62 working against either of the arms 54 or 55 will tend to bias both of the wheels 52 to the same degree in such a manner as to hold the tube 50 as indicated in Fig. 3 of the drawings within the groove 48 to a uniform extent as a specific portion or area of this tube 50 moves along with the wheel 22 as this wheel 22 is rotated.

As the apparatus 10 is operated so that the tube 50 moves in this manner specific regions of the tube 50 move at the same rate as the interior or the groove 48 as the wheel 22 is turned. With the embodiment of the invention shown during each revolution of the wheel 22 a small steel member 64 on the periphery of this wheel 22 moves past a known magnetic switch 66 capable of being actuated by such movement. Each time the wheel 22 turns in this manner the switch 66 is thus actuated. Each time this switch 66 is actuated an electric signal is supplied through it to a known conventional control apparatus 68. When this apparatus 68 is actuated in this way, it serves to operate the apparatus 16 so as to cause the laser beam 18 to be generated or created.

Once this beam 18 comes into existence

it travels along a path as indicated. As it is being created the trimmer 34 is operated in a conventional manner through the operation of an actuating cylinder 69 connected to the control apparatus 68 so as to also be perated in a conventional manner. The beam 18 passing through the trimmer 34 will engage the mirror 36 and will be adjusted by the lens 40 and then will be further reflected by the mirror 42 towards the opening 44. By virtue of the movement of the wheel 22 and the construction described, this beam 18 will be directed towards the opening 44 as long as it is generated and applied as described.

Since the tube 50 moves in synchronism with the periphery of the wheel 22, this beam 18 will thus engage a given area of the tube 50 as this tube 50 moves, as there is no relative motion between the tube 50 and the wheel 22. The member 64 and the switch 66 are positioned so that this beam 18 will be generated at about the point of initial travel of the tube 50 with the periphery of the wheel 22. The control apparatus 68 will operate to continue the generation of the beam 18 until about the point immediately prior to the tube 50 separating from the wheel 22 so that the beam 18 is applied to the tube 50 for as long a period as is reasonably possible.

As the concentrated energy from the beam 18 is applied in this manner the energy from this beam 18 will serve to heat the spot in which it is applied. This will cause a degree of vaporization and a degree of melting in the material in this spot. This energy will thus cause the formation of a hole 70 in the tube 50. As the melting occurs it is considered that normally the heated material moves so that the interior of the hole 70 is defined by a smooth, continuous internal wall of a uniform cross-sectional configuration and that small hubs or bosses 72 are created at both ends of this hole 70 from the material contacted by the beam 18. These hubs or bosses 72 are, of course, created in such a manner that they are integral with and form a part of the tube 50. The actual formation of these hubs 72 is considered to be dependent upon the operation of the apparatus 10. Under some circumstances it may not be formed.

The apparatus 10 is constructed in such a manner that the particular hole 70 is formed during only the initial part of the travel of the tube 50 with the periphery of the wheel 22 so that the beam 18 used will intercept an inner wall 74 within this tube 50 as indicated in Fig. 5 of the drawings during the last portion of the travel of the tube 50 with the wheel 22. It will be realized that in intercepting this inner wall 74 the beam 18 travels through the hole 70 which has been utilized in creating it. As this beam 18 intercepts the wall 74 it will serve t heat the intercepted area r region of the wall 74 so as t create within it another hole corresponding to the hole 70.

The control apparatus 68 is operated by the switch 66 so that each time a hole 70 is to be formed as indicated the apparatus 68 causes actuation of the apparatus 16 creating the beam 18 described. As the beam 18 is created and passes as indicated this beam 18 will pass through the trimmer 34 so that its size, energy and diffraction are controlled in such a manner that the depth to which the beam 18 will penetrate the tube 50 will be regulated to a desired degree. Because of its function, the control apparatus 68 serves as a timing device for the creation of the beam 18 at periodic intervals of desired duration which is synchronized with the movement of the wheel 22.

By virtue of this method of operation a single hole may be created in a length of a seamless or other tube without damaging or effecting a wall or walls of such tube roughly opposite from where the hole is created. This is considered to be quite important. With the apparatus 10 by appropriated adjustment of the mirror 42 a second hole created within an internal wall can be created at either a point in the same plane transverse to the axis of the tube such as the tube 50, or may be created at an angle to such a plane. It is considered preferable to create such a second hole at an angle as indicated so as to avoid direct flow effects involving something of a jet action leading from one hole to another in a tube such as the tube 50 when such a tube is to be employed in irrigation or similar applications.

For such applications it is considered that normally it will be preferable to have all of the holes used of the same diameter. One virtue of the apparatus 10 lies in the fact that it is possible to insert within the control apparatus 68 a conventional counting type mechanism which will actuate the apparatus 16 so that successive beams 18 contain either increased or decreased energy. By regulating the energy in this manner or by controlling the time when beams 18 are applied, it is possible to regulate the dimensions of any holes created so that such successive holes are either of an increased or decreased size.

Extremely small changes in the measurement of holes created in this manner may be quite advantageous in providing tubes such as the tube 50 which are to be utilized in comparatively long lengths in that with such gradations in hole size it is possible to provide tubes which will emit from the various different holes used approximately the same amounts of water even though

there will be a pressure drop in the water within the interiors of such tubes due to their lengths and the configurations to which they may be bent. It is to be realized that extremely small changes in hole diameters are normally required to accomplish such compensations for fluid pressure drop.

In Figs. 7 and 8 of the drawings there is shown a modified wheel 22′ which is extremely similar to the wheel 22 previously described and which can be utilized with the apparatus 10. For conveniences of explanation various parts of the wheel 22′ which are the same or substantially the same as parts previously described are not indicated herein in a separate manner and are designated in the drawings and in the remainder of this specification by the primes of the numerals previously used to designate such parts.

The wheel 22′ is primarily intended to be utilized when it is desired to create a series of holes such as the hole 70 which are located more closely together than possible with the wheel 22. It employs a plurality of the openings 44′, a plurality of the mirrors 42′ and a plurality of the condensing lens 40′. In place of the mirror 36 the wheel 22′ employes a single multi-sided mirror 36′ having sloping faces 76 which are directed to deflect a beam 18′ to any of the sets of lens 40′ and mirrors 42′ towards any of the openings 44′ as there is actuation and operation as previously described. With an apparatus 10 utilizing this wheel 22′ the beam 18′ should be directed towards the mirror 36′ as shown in Fig. 8 of the drawings so as to hit successive faces 76.

From a consideration of the preceding it will be realized that the apparatus 10 is essentially a very simple apparatus which may be utilized in the rapid production of holes as described in tubing of a thermoplastic character. This apparatus 10 may be constructed with a minimum of difficulty and is essentially simple to operate, yet it is extremely effective for its intended purpose.

It is considered that one of the reasons the described apparatus 10 is particularly effective relates to the fact that this apparatus is constructed as indicated so that the laser beam 18 engages the tube 50 at a constant angle as this beam 18 is applied to the tube 50. This is considered to contribute to the desired character of holes such as the hole 70 created as indicated in the preceding discussion. It will be realized that this angle can be adjusted as indicated in the preceding discussion. In a similar way the length of time that the beam 18 engages a tube such as the tube 50 can be varied through conventional type operation of the control means 68 so that at successive periodic intervals a hole will not be created in the internal wall 74.

By providing appropriate, conventional lens systems, such as by using ther than a condensing lens 40, the beam 18 may be made t assume a conical type of shape in the region where it engages either the tube 50 or the internal wall 74 so that either the hole created in the exterior of the tube 50 or the hole created in the internal wall 74 will be larger than the other in accordance with the diameter of the beam as it creates either of these holes. Obviously the larger the beam creating a specific hole, the more contact with the beam necessary to create a hole.

WHAT WE CLAIM IS:—

1. Apparatus for making a hole in a member, the apparatus comprising: moving means for moving the member through a hole-making station; and directing means for directing a moving laser beam against a region of the member as that region passes through the hole-making station, the directing means being synchronized with the moving means in such a manner that, in use, the point of contact of the laser beam with the member moves through the hole-making station in the same direction that the said region moves through the hole-making station whereby the said point of contact remains within the said region throughout the movement of the said region through the hole-making station and the laser beam forms a hole in the member in the said region.

2. Apparatus according to claim 1 wherein the moving means continuously moves the member through the hole-making station.

3. Apparatus according to claim 1 or claim 2 wherein the directing means is synchronized with the moving means in such a manner that there is substantially no relative movement between the point of contact of the laser beam with the member, and the member as the said region moves through the hole-making station.

4. Apparatus according to any preceding claim wherein the moving means moves the said region along an arcuate path through the hole-making station.

5. Apparatus according to claim 4 wherein the arcuate path has a centre of rotation and the directing means rotates the laser beam about the centre of rotation as the said region moves through the hole-making station.

6. Apparatus according to any preceding claim wherein the directing means directs the laser beam against each of a plurality of regions of the member as each of the said regions moves through the hole-

making station to form a plurality of spaced apart holes in the member.

7. Apparatus according to claim 6 including means for automatically varying the power of the beam of the point of contact with the member to produce a series of holes of regulated varying dimensions.

8. Apparatus according to any preceding claim including means for shaping the laser beam into a conical beam to contact with the member.

9. Apparatus according to any preceding claim wherein the moving means comprises a rotatably mounted wheel having a periphery for receiving the member, and the directing means comprises at least one mirror mounted for rotation with the wheel.

10. A method of making a hole in a member comprising the steps of moving the member through a hole-making station; and directing a moving laser beam against a region of the member as that region passes through the hole-making station to form a hole in the member, the movement of the laser beam being synchronised with the movement of the member in such a manner that the point of contact of the laser beam with the member moves through the hole-making station in the same direction as the said region moves through the hole-making station whereby the said point of contact remains within the said region throughout the movement of the said region through the hole-making station.

11. A method according to claim 10 wherein there is substantially no relative movement between the point of contact of the laser beam with the member, and the member, as the said region moves through the hole-making station.

12. A method according to claim 10 or claim 11 wherein the member is moved in an arcuate path through the hole-making station.

13. A method according to claim 12 wherein the arcuate path has a centre of rotation and the step of directing a laser beam comprises rotating the laser beam about the centre of rotation as the said region moves through the hole-making station.

14. A method according to any f claims 10 to 13 including the step of directing the laser beam at each of a plurality of regions of the member as each of the said regions moves through the hole-making station to form a plurality of spaced apart holes in the member.

15. A method according to claim 14 wherein the dimensions of the holes in the member are varied by varying the energy directed against successive regions of the member along the length thereof.

16. A method according to claims 10 to 15 wherein the member is a hollow tubular body and the laser beam is directed against the body for a period which is insufficient to form a hole in the external wall of the body opposite to the wall in which the hole is produced by the laser beam.

17. A method according to claim 16 wherein the tubular body includes an interior dividing wall, and the laser beam is directed against the body for a period which is sufficient to produce a hole in the dividing wall after a hole in the exterior wall has been produced.

18. A method according to claim 17 wherein the laser beam is directed at the tubular body obliquely to the longitudinal axis thereof, whereby the hole in the dividing wall is axially offset from the hole in the exterior wall.

19. Apparatus for making a hole in a member, substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

20. A method of making a hole in a member, substantially as hereinbefore described with reference to the accompanying drawings.

A. A. THORNTON & CO.,
Northumberland House,
303-306 High Holborn,
London W.C.1.

Printed for Her Majesty's Stationery Office by Bdrgess & Son (Abingdon), Ltd.—1976.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1450251 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

FIG. 1.

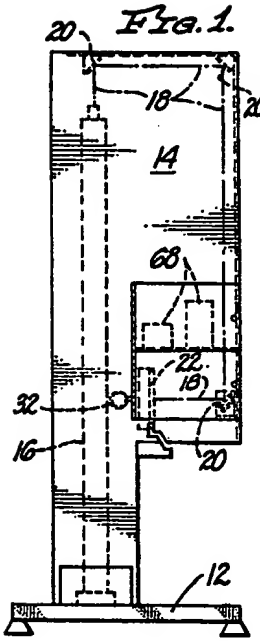


FIG. 2.

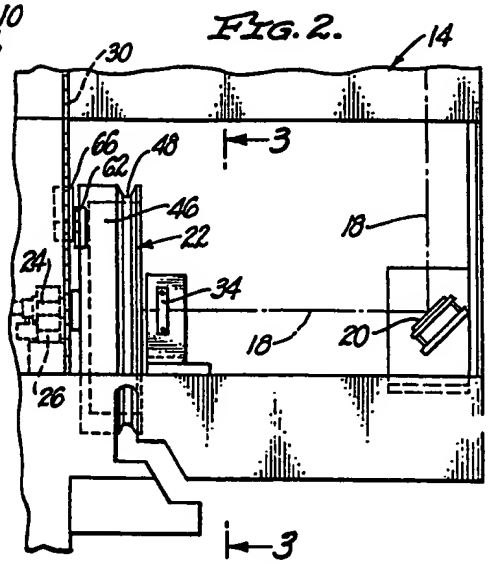


FIG. 3.

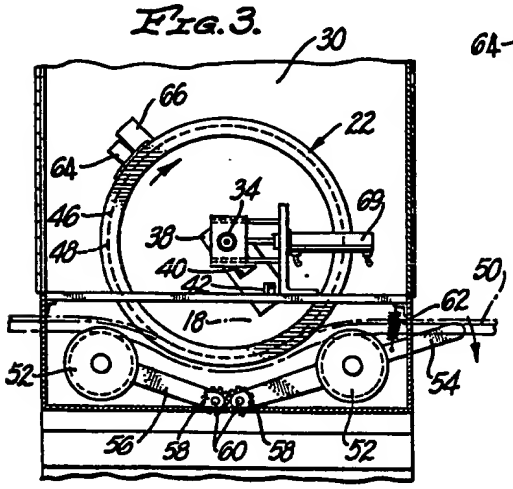


FIG. 4.

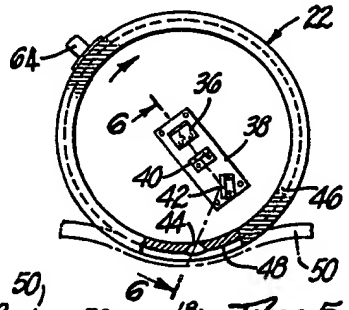
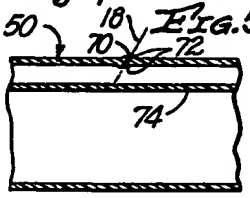


FIG. 5.



1450251 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

FIG. 6.

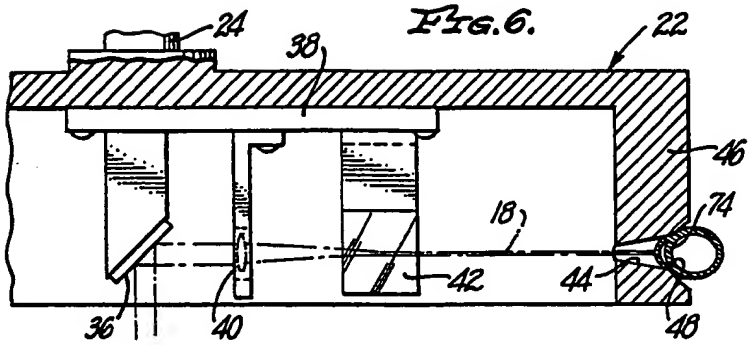


FIG. 7.

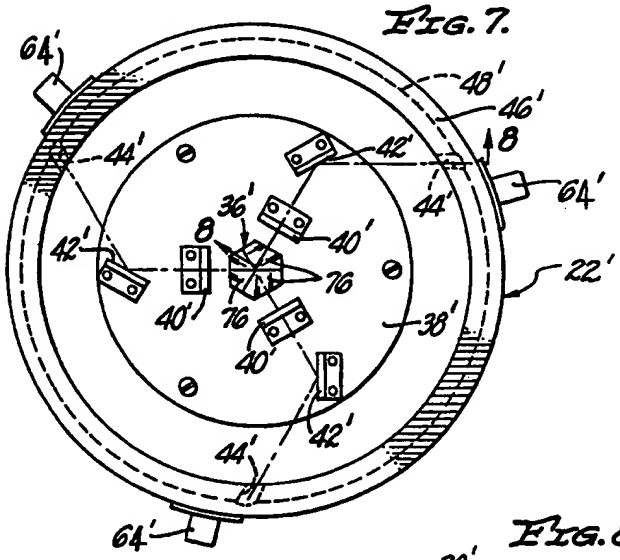


FIG. 8.